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ANATOMY AND FUNCTION OF THE STING APPARATUS OF STINGLESS BEES (HYMENOPTERA: APIDAE: APINAE: MELIPONINI)

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Abstract.—The anatomy and function of the sting apparatus of five species of stingless bees in the Meliponini are described. All species studied have a sting apparatus, although the stylet is reduced. The rest of the skeletal parts are present, and valvulae III are especially well developed.

A nearly universal character in Aculeate Hymenoptera is the presence in the female of a sting apparatus which has defensive and offensive functions. Traditionally bees in the tribe Meliponini are regarded as lacking a sting (Kerr and Lello, 1962, for example), and they are commonly called stingless bees. However, meliponines have a sting apparatus although it is reduced or atrophied as Schwarz (1948) has pointed out.

Two basic functional parts can be distinguished in the structure of the sting apparatus of Aculeate Hymenoptera: (1) Skeletal with muscles and (2) glandular. Details of the skeletal and glandular parts have been described by many authors (D'Rozario, 1940; Oeser, 1961; Robertson, 1968; Radović, 1976; Richards, 1977; Radović and Hurd, 1980), and they are especially well known for the genus *Apis* (Snodgrass, 1935, 1956).

The glandular part of the sting apparatus of stingless bees was studied by Kerr and Lello (1962) and Lello (1976). However, the skeletal parts are less well known, and, except for reports that they are "reduced," "atrophied," or "functionless," the existing literature does not contain detailed descriptions or illustrations. Therefore, I have concentrated on the skeletal parts of the sting of stingless bees, observed changes in its structure, and determined which skeletal parts are reduced and which are well developed.

Materials and Methods

Five species of stingless bees were studied: *Melipona flavipennis* Smith from Peru; *M. interrupta grandis* Guérin-Menéville from Bolivia; *Trigona fulviventris* Guérin-Menéville from Mexico; *T. amalthea* (Olivier) from El Salvador; and *Lestrimelitta limao* Smith from Panama.

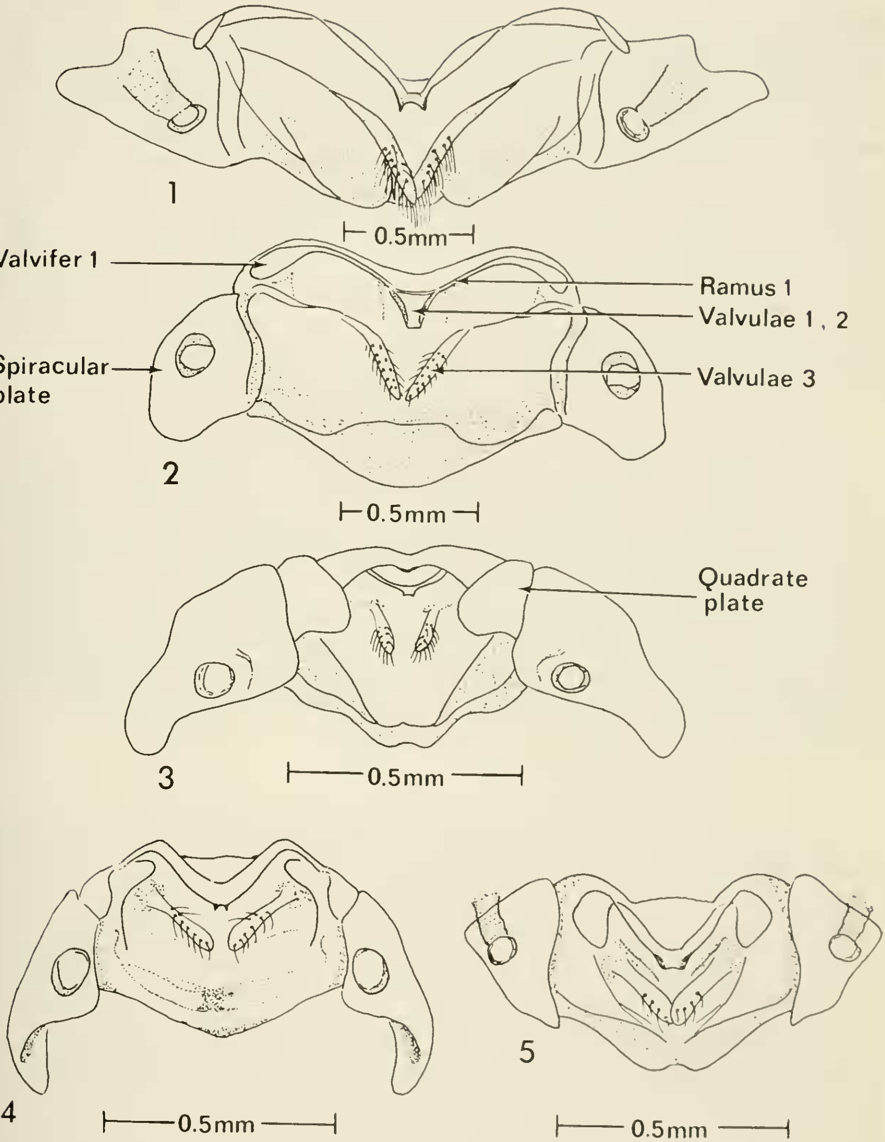
Dry specimens were softened in a relaxer before dissection. Because of their small size and delicate structure, dissection was conducted in 70% ethyl alcohol under a binocular microscope. After dissection, the sting apparatus was taken through series of solutions for cleaning and dehydration (Radović and Hurd, 1980). Lastly, the skeletal parts were mounted in Canada balsam on a microscope slide. All illustrations were prepared by the author with use of a Bausch and Lomb Tri-Simplex microprojector.

Results and Discussion

The sting apparatus of Apidae are modified skeletal parts of the 8th and 9th abdominal segments. All five species of stingless bees examined have a sting apparatus, the stylets of which are represented by remnants of valvulae I and valvulae II (Figs. 1–5). With such a reduced stylet structure, it is obvious that the stinging function is lost. All five species have arched rami varying in shape and thickness continuing from the base of stylet. The rami end in a triangular plate (valvifer I). The size and shape of the triangular plate varies, but it is largest in *Lestrimelitta limao* (Fig. 5). Oblong plates are membranous and very difficult to detect in all five species. Quadrate plates, remnants of the 9th abdominal tergum, are well developed in *Trigona* (Figs. 3, 4) but are membranous in the two species of *Melipona* (Figs. 1, 2) and in *Lestrimelitta limao* (Fig. 5). Each of the five species have well-developed spiracular plates which are remnants of the 8th abdominal tergum. The last abdominal spiraculum is evident on each of the spiracular plates. In all five species, the middle part of the 9th abdominal segment is folded over the base of the sting and is membranous and thin.

Valvulae III are especially well developed in five species. Females of stinging bees and of other Aculeate Hymenoptera have the inside of valvulae III concave for covering and protecting the stylets; sensory bristles are also present, especially on the top (Maschwitz and Kloft, 1971). However, valvulae III of the stingless bees examined are robust, rounded, and straight inside, and sensory bristles are distributed along the entire top. Valvulae III of stinging bees have a sensory role, and it is assumed that they contact the body of the victim before the stinging act (Snodgrass, 1956). Rathmayer (1962, 1978) stated that the function of valvulae III is to detect nonsclerotized cuticular spots on the body of the victim, and he believed that the bristles, especially those at the top, are mechanoreceptors. But what is the function of valvulae III and their numerous bristles in stingless bees? The many well-developed bristles on valvulae III may act as mechanoreceptors in stingless bees as well, but what is their purpose since the stylet is reduced and there is no stinging?

Stingless bees, although lacking a functional sting apparatus, show a wide range of defense mechanisms which they use to protect their colonies (Kerr and Lello, 1962; Michener, 1974). They use mass attack into the eyes, nose,



Figs. 1–5. Sting apparatus, anterodorsal view. 1, *Melipona flavipennis*. 2, *M. interrupta grandis*. 3, *Trigona fulviventris*. 4, *T. amalthea*. 5, *Lestrimelitta limao*.

ears, or hair of animals or people endangering their colonies (Michener, 1974). Some species of *Trigona* and *Melipona* have powerful mandibles that can penetrate the skin of animals and people. Species of the subgenus *Trigona* (*Oxytrigona*) have special glands at the base of the mandibles that secrete a venom that may cause lesions where the mandibles penetrate (Michener, 1974). There may be certain links between such defense mechanisms and the well-developed valvulae III of stingless bees. i.e. the defensive and aggressive acts may come after contact of the bristles with the body of the victim. Schwarz (1948) stated that stingless bees sometimes simulate the stinging act by pressing the top of the abdomen onto the body of the victim. This simulation of the stinging act may be caused by the stimulation of the mechanoreceptors on the bristles of valvulae III.

Conclusions

Based on the study of the structure of the sting apparatus of five species of Meliponini, (1) stingless bees, contrary to their name, have a sting apparatus; (2) stingless bees show reduction and atrophy of the stylet (valvulae I and II) and this part is functionless; (3) the basal parts of the sting apparatus are developed; (4) valvulae III are especially well developed, rounded along their length, not concave inside, and have numerous bristles which my act as mechanoreceptors that stimulate certain defense mechanisms; and (5) except for similarities in general structure, all five species studied show morphological differences in some parts of the sting apparatus, and these structures may have some taxonomic importance.

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